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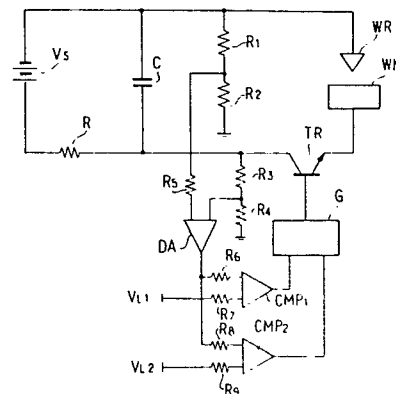
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54 A power source for an electric discharge machine.

57 A power source for a wire-cut electric discharge machine is designed to increase the cutting speed and improve the surface smoothness of a work piece. A capacitor C for supplying a discharge energy across a wire electrode WR and the workpiece WK is always charged by a DC power supply Vs, and the charged voltage is applied across the machining gap via a switching element TR. The switching element TR is turned ON when the charged voltage of the capacitor C reaches a predetermined level, and turned OFF when the charged voltage becomes substantially zero, permitting rapid charging of the capacitor C and the generation of a uniform discharge energy.

FIG.3



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A POWER SOURCE FOR AN ELECTRIC
DISCHARGE MACHINE

The present invention relates to a power source for producing a discharge, for example between a wire electrode and a workpiece in a wirecut electric discharge machine.

A known power source of this kind is such, for example, as shown in Fig. 1. In Fig. 1, reference character WR indicates a wire electrode; WK designates a workpiece; Vs identifies a DC power supply; C denotes a capacitor; R represents a charging resistor; and Q shows a switching element such as a transistor or the like. By repeating ON-OFF operation of the switching element Q, the capacitor C is charged by the DC power supply Vs via the charging resistor R. The charged voltage is applied across the wire electrode WR and the workpiece WK and a discharge current of the capacitor C flows, as a discharge, in a discharge gap defined between the wire electrode WR and the workpiece WK, performing electric discharge machining of the latter.

For the repetition of a stable discharge in electric discharge machining, a necessary and sufficient discharge suspension period is required for each discharge and, at the same time, care should be taken in the voltage application at the start of redischarge. The insulation recovery characteristic of the discharge gap after a discharge is such as schematically indicated by the solid line A in Fig. 2. When a voltage higher than

the curve A (which voltage will hereinafter be referred to as the redischarge voltage) is applied across the discharge gap, it is likely that a discharge is repeatedly produced at the same position or that an arc discharge results.

With a view to settling this problem, in the prior art circuit of Fig. 1 the charging time constant of the capacitor C is selected large so that its charging characteristic curve may not exceed the insulation recovery characteristic curve A, that is, so that the redischarge voltage as indicated by the broken line B in Fig. 2 is achieved. Accordingly, the frequency of discharge per unit time cannot be increased and the cutting speed cannot be raised. Furthermore, the conventional circuit is a dependent discharge circuit, which may sometimes be discharged before the capacitor C is sufficiently charged and consequently the discharge energy varies for each discharge, resulting in the defect that a satisfactory surface smoothness of the workpiece is difficult to obtain.

According to the invention there is provided a power source for an electric discharge machine, the power source comprising:

a capacitor which is to be charged by a power supply for supplying discharge energy across an electrode of the machine and a workpiece when the power source is in use; a switching element inserted in a discharge path of the capacitor; and control means operable for turning ON the switching element when a charge voltage of the capacitor reaches a predetermined level, and for turning OFF the switching element upon completion of a discharge.

A preferred embodiment of the present invention provides a power source suitable for use in wire-cut electric discharge machine, which permits an increase in the frequency of discharge per unit time in the working gap, thereby to raise the cutting speed. It

also may provide a uniform discharge energy for each discharge in the working gap, thereby improving the surface smoothness of a workpiece.

The charging time constant of the capacitor
5 may be selected small to such an extent that the charging voltage of the capacitor exceeds the redischage voltage in the working gap between the wire electrode and the workpiece at an early stage of the charging of the capacitor. The switching element may
10 be turned ON at the moment when the charge voltage of the capacitor becomes small relative to the re-discharge voltage as a result of its abrupt increase.

For a better understanding of the present invention and to show how it may be put into effect
15 reference will now be made, by way of example, to the accompanying drawings in which:

Fig. 1 is an electric circuit diagram showing a conventional wire-cut electric discharge machine power source;

20 Fig. 2 is a graph showing the relationship between the insulation recovery characteristic of a discharge gap and the charging characteristic of a capacitor;

Fig. 3 is a block diagram illustrating
25 the principal part of an embodiment of the wire-cut electric discharge machine power source of the present invention;

Fig. 4 is a graph showing variations in a
charged voltage V_C of a capacitor C, a gap voltage V_G ,
30 a discharge current I and the operation of a switching element TR with time in the case where the power source of Fig. 3 was operated; and

Fig. 5 is a graph showing the relationship
between the insulation recovery characteristic of the
35 discharge gap and the gap voltage V_G .

Figs. 1 and 2 have already been described in detail.

Fig. 3 illustrates in block form the principal part of an embodiment of the present invention, in which the parts corresponding to those in Fig. 1 are identified by the same reference characters. In Fig. 3, reference character TR indicates a transistor or like switching element; R_1 to R_9 designate resistors; DA identifies a differential amplifier; CMP_1 and CMP_2 denote comparators; V_{L1} and V_{L2} represent reference voltages; and G shows a gate circuit.

Unlike the circuit of Fig. 1, the present embodiment is arranged so that the capacitor C may always be charged by the DC power supply V_s via the charging resistor R, and that charges stored in the capacitor C are applied across the wire electrode WR and the work WK via the switching element TR inserted in the discharge path of the capacitor C. The charged voltage of the capacitor C is detected by the resistors R_1 to R_5 and the differential amplifier DA, and provided to one input terminal of the comparator CMP_1 via the resistor R_6 and to one input terminal of the comparator CMP_2 via the resistor R_8 . The comparator CMP_1 makes a comparison between the output from the differential amplifier DA and the reference voltage V_{L1} applied to the other input terminal, thereby to detect that the charged voltage of the capacitor C has reached a predetermined level suitable for discharging. The comparator CMP_2 compares the output from the differential amplifier DA with the reference voltage V_{L2} applied to the other input terminal, thereby to detect that the charged voltage of the capacitor C has been reduced to substantially zero. The gate circuit G performs logical processing of the outputs from the comparators CMP_1 and CMP_2 to achieve ON-OFF control of the switching element TR.

Fig. 4 shows variations in the charged voltage V_C of the capacitor C, the gap voltage V_G , the discharge current I and the operation of the switching element TR with time when the device of Fig. 3 was

operated. A description will be given, with reference to Fig. 4, of the operation of the embodiment of Fig. 3.

When the capacitor C is charged by the DC power supply Vs with the characteristic indicated by the curve V_C in Fig. 4 and its potential reaches a predetermined level H suitable for discharging, this is detected by the comparator CMP_1 and the gate circuit G turns ON the switching element TR. As a consequence, the charged voltage V_C of the capacitor C is applied as the gap voltage V_G across the wire electrode WR and the workpiece WK and, after a very short period of time, the discharge current I flows in the discharge gap to effect electric discharge machining of the workpiece WK. When the discharge is started, the charged voltage of the capacitor C rapidly drops and it is detected by the comparator CMP_2 that the charged voltage becomes lower than the predetermined level L, i.e. becomes substantially equal to zero. The gate circuit G detects the completion of the discharge from the output from the comparator CMP_2 and quickly turns OFF the switching element TR and, by this operation, the capacitor C is charged again to be ready for the next discharge.

Fig. 5 is a graph showing the relationship between the insulation recovery characteristic of the discharge gap and the gap voltage V_G . It appears from Fig. 5 that even if the capacitor C is charged so rapidly that the charged voltage exceeds the redischarge voltage A as indicated by the curve V_C , the voltage is not provided across the discharge gap because the switching element TR is in the OFF state in the region above the redischarge voltage, and that the voltage is applied across the discharge gap at a moment when the charged voltage V_C of the capacitor C has become lower than the redischarge voltage A. Thus it can be seen from Fig. 5 that the switching element

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TR is turned ON at a moment when the charged voltage of the capacitor C is small relative to the redischarge voltage A, as a result of an abrupt increase in the latter. Since the redischarge voltage across the discharge gap undergoes various changes during machining, the arrangement described previously is not quite free from abnormal discharge. By a suitable selection of the level H in Fig. 4 and the charging time constant of the capacitor C in view of an average redischarge voltage characteristic, however, sufficiently stable discharging is possible and, in addition, the frequency of discharging can markedly be increased. Moreover, since the discharge is started when the charged voltage V_C of the capacitor C reaches a predetermined level, the energy for each discharge is uniform.

As will be appreciated from the foregoing description, since no voltage is applied across the discharge gap until the switching element TR is turned ON, even if the capacitor is rapidly charged, there does not occur an abnormal discharge as in the prior art; accordingly, the frequency of discharging can be raised, permitting an increase in the cutting speed. Furthermore, since the energy for each discharge is made uniform, a worked surface of good quality can be obtained.

It will be apparent that many modifications and variations may be effected without departing from the scope of the novel concepts of the present invention.

Claims:

1. A power source for an electric discharge machine, the power source comprising:
a capacitor which is to be charged by a power supply for supplying discharge energy across an electrode of the machine and a workpiece when the power source is in use; a switching element inserted in a discharge path of the capacitor; and control means operable for turning ON the switching element when a charged voltage of the capacitor reaches a predetermined level, and for turning OFF the switching element upon completion of a discharge.
2. A power source according to claim 1, wherein the control means comprises: a differential amplifier for detecting the charged voltage of the capacitor; a first comparator for comparing the output from the differential amplifier and said predetermined level to detect when the charged voltage of the capacitor reaches said predetermined level; a second comparator for comparing the output from the differential amplifier and a reference voltage to detect when the charged voltage of the capacitor becomes substantially zero; and a gate circuit which is to be supplied with the outputs from the first and second comparators thereby to generate a control signal for the switching element.
3. A power source according to claim 1 or 2, wherein the charging time constant of the capacitor is selected small to such an extent that when the power source is in use the charged voltage exceeds a redischarge voltage across a machining gap defined between the electrode and the workpiece at an early stage of charging the capacitor, and wherein the switching element is arranged to be turned ON at a moment when the charged voltage of the capacitor is small relative to the redischarge voltage, as a result of an abrupt increase in the latter.
4. A power source according to any one of the preceding claims, which is for a wire-cut electric discharge machine.

5. An electric discharge machine comprising a power source according to any one of the preceding claims.
6. An electric discharge machine according to claims 4 and 5, which is a wire-cut electric discharge machine.

FIG.1

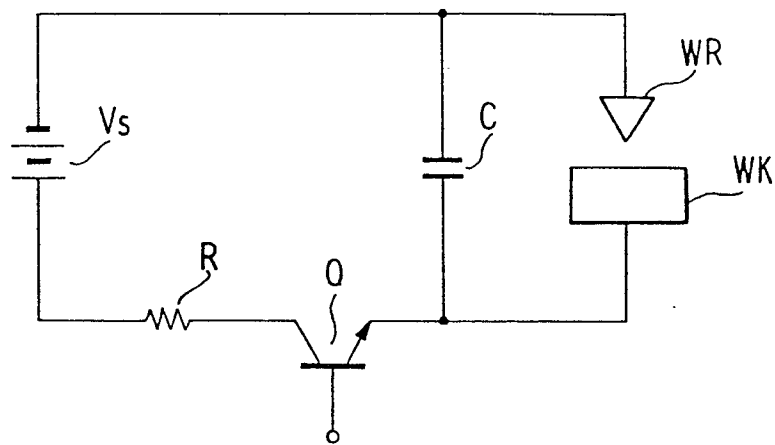


FIG.2

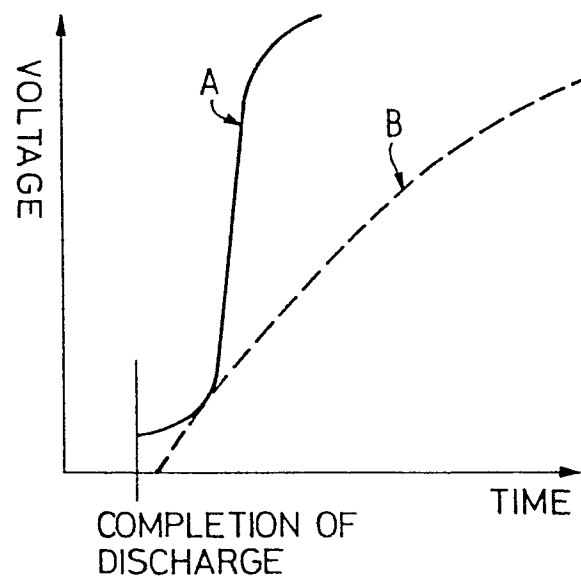


FIG.3

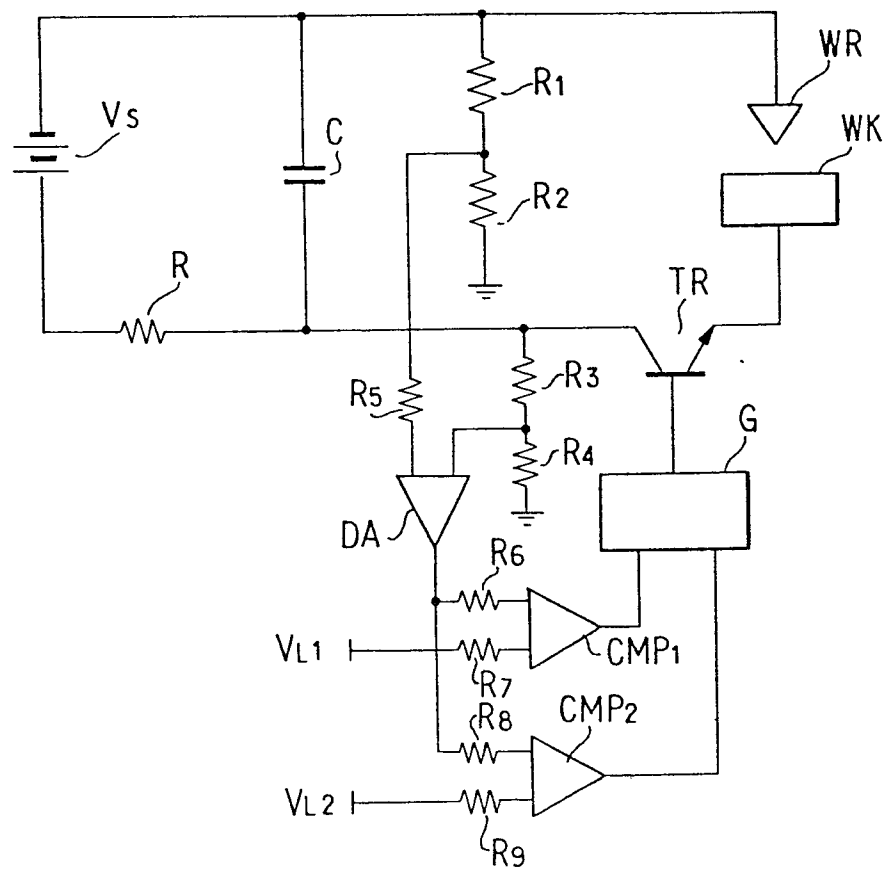


FIG.4

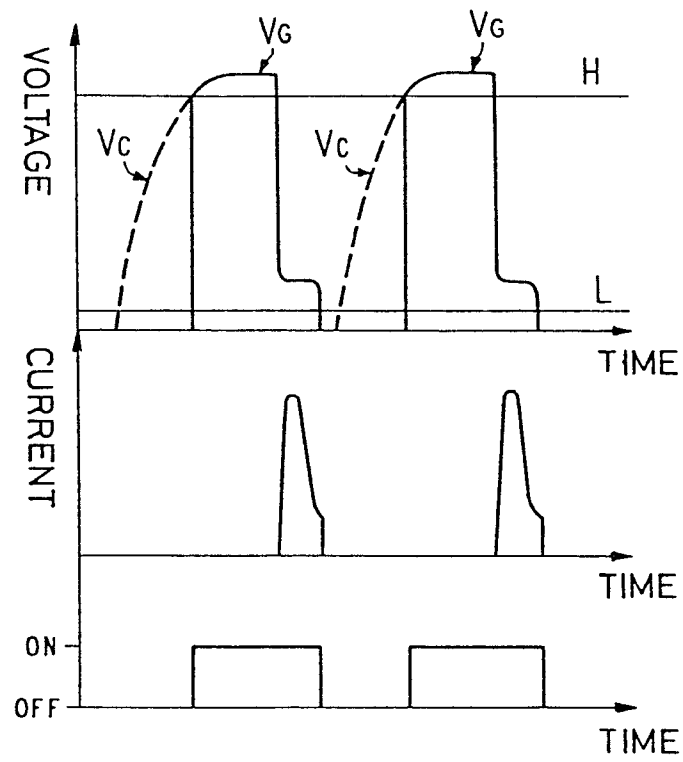
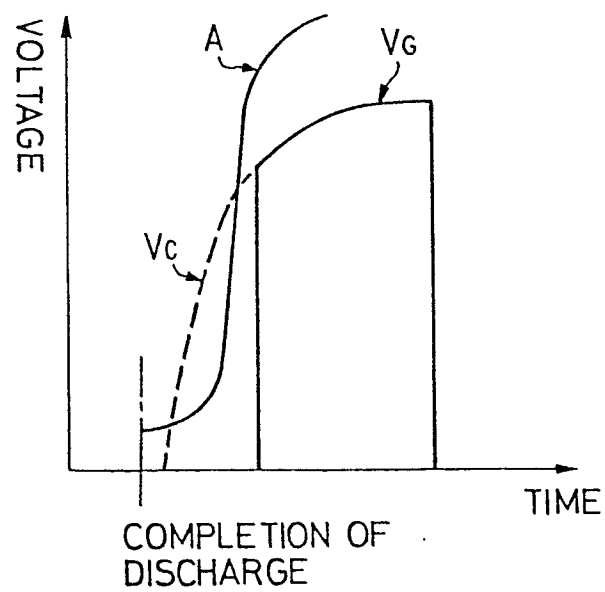


FIG.5





DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
	<u>FR - A - 2 242 191</u> (ATELIERS DES CHARMILLES) * Page 4, lines 11-32 * & US - A - 3 956 609 --	1	B 23 P 1/08
	<u>FR - A - 1 354 354</u> (ELOX) * Claim 1 * & US - A - 3 485 987 ----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl. ³)
			B 23 P 1/08
			CATEGORY OF CITED DOCUMENTS
			X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons
<input checked="" type="checkbox"/> The present search report has been drawn up for all claims			&: member of the same patent family, corresponding document
Place of search The Hague		Date of completion of the search 31-03-1981	Examiner DAILLOUX